THE FACULTY OF TROPICAL MEDICINE

UNIVERSITY OF MEDICAL SCIENCES

FINAL PROGRESS REPORT

INVESTIGATION ON THE PATTERNS OF EPIDEMIOLOGY AND ENDEMICITY OF THE DISEASES OCCURRING DUE TO LARGE SCALE ENVIRONMENTAL CHANGES IN NOR THEAST THAILAND

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ABSTRACT

Investigations were carried out between 1967 - 1969 on the patterns of the epidemiology and endemicity of the diseases occurring in the nine relevant areas in the vicinity of Ubol-Ratana and Non Wai Dams of Khon Kaen province in Northeast Thailand. There was a high prevalence rate for intestinal parasitic infections and for liver fluke infections in all the areas studied; 52.0 - 80.6 per cent of the population (indigenous and settlers) were infected with helminths and 9.2 - 19.3 per cent with protozoa. The incidence of opisthorchiasis was rather high (27.5 - 69.6 per cent), while those of hookworm infections were moderate (6.9 - 40.6 per cent). The intestinal flukes were prevalent in some areas (10.1 - 16.2 per cent). Giardia infection was also found in many villages (2.4 - 7.9 per cent), while E.histolytica infection was surprisingly very low (0 - 0.2 per cent).

There was no evidence of the presence of schistosomiasis and paragonimiasis in the areas under study. Gnathostomiasis was an unimportant disease among the villagers.

Leptospirosis is likely to be an important disease in both the resettlement and irrigation areas, since the disease has been found in man (12 - 19 per cent by serum agglutination test) and among rats (16 - 18 per cent by kidney culture).

The incidence of scrub typhus among rats was 6.4 - 21.4 per cent, and Leptotrombidium deliensis, the important vector of this disease in Thailand, was also found in the areas studied.

Angiostrongylus adult worms were found in rats in the nine areas studied, and their infective larvae were observed in Pila snails (3.2 - 5.2 per cent). Therefore, Angiostrongylus infection is a potential threat to the people living in all the areas since raw snails are frequently eaten by them.

Malaria is unlikely to be a risk, as at the time of study the incidence of infections among the people in all the areas was rather low (0.2 - 2.1 per cent).

It is suggested that surveys should be continued and repeated, to provide base line data for studying the progress and for the disclosure of some salient points in the control of particular infections. However, at present public health measures to prevent the spreading of some of these diseases should be introduced in various ways in some of the areas.

CONTENTS

BODY OF THE REPORT

INTRODUCTION

It has been established that the diseases which may occur following the construction of dams and water reservoirs and development of irrigation, include those of general nature effecting wide areas of the country (such as malaria and hookworm infections) and those of limited distribution depending on local agents and circumstances (such as leptospirosis, scrub typhus, opisthorchiasis, etc.). It was decided that studies of these potential infections which are vital to the future socio-economic development in the rural areas and should be undertaken on the spot where such developments were taking place.

The Government of Thailand, according to the plan of economic development of the country, constructed Ubol-Ratana Dam (for electricity) and Nong Wai Dam (for irrigation) at Nam Pong district of Khon Kaen province in Northeast Thailand in 1963 (map 1 & 2), and they have been in operation since 1966 - 1967. As the results of this, a man-made water reservoir or lake of about 400 square kilometres was created and the topography such as forests, fields, villages, swamps, etc. were changed which in turn affected changes in the natural fauna such as insects, water animals, fowls and cattle of

the area. The movement of the population in and out of the area due to resettlement of the villagers and irrigation schemes may result in the spreading of existing diseases or on the occurrence of new diseases in the area. It is well agreed that such health problems can be important obstacles in the socio-economic development of the country in general.

Our objective was to determine the incidence of communicable diseases in the key areas and, where necessary, to propose preventive measures for execution by the Ministry of Public Health. In this way the health of those villagers involved in the resettlement and irrigation schemes could be better safeguarded now and also in the future, and the medical problems involved with the associated movements of population could be assessed and dealt with. The assessment of the results of the surveys in the area will be made easier because of the availability of information on the medical situation in the areas from which population movement is occurring or anticipated.

The major medical problem on which the Faculty of Tropical Medicine was concentrating in the Ubol-Ratana development area and the associated Nong Wai irrigation scheme were communicable diseases of all nature particularly the intestinal parasitic and hepatic infections and certain spirochaetal and rickettsial infections. These included opisthorchiasis which caused liver damage; hookworm infections which

were common among farmers and agricultural workers; malaria which was acute and being easily transmissible; leptospirosis and scrub typhus, both being potentially dangerous diseases which already existed to some extent among the indigenous human population and was found to be common in the rodents in the rice fields and in the irrigation areas. Many of these diseases, often on a big scale, can affect the indigenous or migrating populations, or both, with the consequent serious impariment of their health. This can lead to economic loss through loss of man-hours of labour and through low individual efficiency, which could result in a significant lowering of general living standards. The possibility of the latter situation occurring in the presence of the increased socioeconomic opportunities for improvement of living standards offered by the operation of the dam project, is paradoxical and should not be allowed to occur.

In this report the surveys carried out by the Faculty of Tropical Medicine has been limited in its content and extent due to a limited amount of funds available and to the short period of time (the work was carried out for 2 years during June 1967 - May 1969). The procedures for the surveys were made by standard conventional methods, involving many visits of personnel to the relevant areas and much hard field work. The results, however, have demonstrated the value of obtaining basic information in the areas of operation and

have provided the data illustrating the local situation with regard to common endemic gastro-intestinal and general infections in relation to the human situation and to the animal reservoirs and vector. They also indicate the major problems which require attention in the various geographical areas of development such as re-settlements and irrigation projects. More-over, on a long term basis, the initial survey and the subsequent re-surveys in the same areas will act as a check on the effectiveness or otherwise of public health measures, or for the implementation of pilot control schemes.

DESCRIPTION OF THE AREA

Khon Kaen province is situated 425 kilometres by road from Bangkok on a latitude 16° - 17° N. in the control area of Northeast Thailand (map 1). Two-third of the province are high-lying plain areas, the mean height being about 165 metres above sea level. The western part of the area is forested and mountainous declining towards the east and the south, where rice and crops are growing. There is a moderate relative humidity and rainfall is usually available in the rainy season (June - October). It is very hot in summer and rather cold and dry in winter. Rice and other crops can be cultivated only during the rainy season.

The province covers an area of 13,404 square kilometres and is divided into 10 districts which are subdivided into 96 cantons and 1,363 villages. The population numbers about 900,000, nearly all of whom are Thai who earn their living by cultivation of rice, jute and other agricultural products, and by raising cattle, buffaloes and poultry. A river, "Nam Pong", starting from the high hilly western part of the province, runs through the northern and eastern parts. This river is usually flooded during the rainy season, but is nearly completely dry during late winter and summer. It is expected that as a result of the construction of the dams in two places in the northern part of Khon Kaen, (map 2, Ubol-Ratana Dam for electricity

and Nong Wai Dam for irrigation), water will be available freely throughout the year in the area.

GENERAL ENVIRONMENT AFTER CONSTRUCTION OF THE DAMS

After the completion of the construction of the dams in 1966-1967, a water reservoir of 400 square kilometres with the water capacity of about 2,500 million cubic metres was created in the northeastern part of Khon Kaen (map 2). In the northern bank of this reservoir lies a district called "Non Sang" of Udon-Thani province (area A), consisting of 62 villages with population of 50,000. The land of this district is lower than the water level of the reservoir, and because of this an earthern wall was built around the southern part of the district for protection of being flooded. Most of the villagers earn their living by fishing as well as by rice and crop cultivation. About 5 kilometres northeast to this district, an area of 40,000 rais (20,000 acres) has been allocated for self-help resettlemtn villages (area B). It is a foothill land along the east side of Pu-Kao mountain range surrounded by thinly forested areas. In this area hundreds of new families have settled, each family being provided with a piece of land of about 10 rais (5 acres).

Nong Wai Dam is situated about 35 kilometres down stream of Nam Pong River and to the east of Ubol-Ratana Dam (map 2).

It is built for irrigation purpose. The water level in the river above the Dam is regulated so that there will be enough supply of water for irrigating the agricultural area of 200,000 rais (100,000 acres).

As a result of the construction of the dams mentioned above, changes in the environment of Non Sang district of Udon-Thani province, Nam Pong and Muang districts of Khon Kaen province were as follows:-

(1) Man-made lake (map 2). The water reservoir is the breeding place for many kinds of fresh-water fish including cyprinoid fish which is the important second intermediate host of Opisthorchis viverrini*. In addition, the population of various fresh-water snails is expected to increase, many species of them being intermediate hosts of parasitic helminths. The prevalence of liver fluke infections and other parasitic diseases in the population of this area may thus be increased remarkably.

(2) The status of the population in Non Sang district. Many of the people who live in Non Sang district (map 2, area A) close to the lake have changed their occupation from farming to

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* It was reported elsewhere that 20-30% of cyprinoid fish from Nong-Harn Lake, Skolnakorn province of Northeast Thailand harboured metacercariae of O. viverrini.

fishing due to the abundance of fish in the water reservoir,. There is also an increase in agricultural products in this district due to the availability of water, and thus the economic status of the people in the area has much improved. However, this does not mean that their health would also improve for the better; it might on the other hand turn to the worse due to many parasitic and other diseases. The water reservoir would result in an increase of fresh-water fish and the snail population which are the intermediate hosts of liver flukes and other parasitic diseases. The eating custom of the people has not changed. They still like eating raw fish, fermented meat or uncooked snails, and thus are liable to contract liver fluke and intestinal parasitic infections easily. The population of rats would also increase. As it is well known that these animals are the reservoirs of leptospirosis, scrub typhus and certain parasitic diseases, the incidence of these diseases may also increase to a great extent.

The self-help resettlement villages in Non Sang district (map 2, area B), are adjacent to the forested hilly areas; therefore malaria may occur among the villagers.

(3) The Self-help resettlement villages in Ban Kok Soong, Nam Pong district, (map 2, area D). An area of about 250,000 rais (125,000 acres) has been allocated as the self-help resettlement land for the people moving from the villages flooded with the water of the lake. It is a sloping land with high and low elevations toward

the Nam Pong River. The land is fertile. It is expected that the number of the new settlers would be about 2,000 families or 10,000-12,000 people. They may introduce some new diseases into the area, and at the same time they are non-immune to the pre-existing local diseases, and thus exposing themselves to the potential risk of contracting such diseases.

(4) The land to be irrigated with water from Nong Wai Dam. (map 2). This is triangular area to be irrigated throughout the year with water from Nong Wai Dam. There would be a marked increase in the number of fresh water fish and snails as well as in the number of dogs and rats. The health problems among the people in this area will probably be the same as in other areas mentioned earlier.

The diseases which may occur and spread among the people after the construction of the dams are as follows:-

1. Liver fluke infection

Bithynia snails and fresh water fish are the first and the second intermediate hosts of opisthorchiasis respectively. There would be an increase in the population of these aquatic animals in the water reservoir, and if the people in this area still continue with the habit of eating raw fish, there would be an increase in the liver fluke infections among them.

2. Intestinal helminthic infection. The incidences of hookworm infections, strongyloidiasis, ascariasis, trichuriasis and intestinal trematode infections are usually high in an area with good irrigation facilities and in agricultural communities.

3. Schistosomiasis (blood fluke infection). Fresh water snails are the vector of schistosomiasis. As far as we know, schistosomiasis in Thailand has been found only in the South. However, we have not yet carried out any surveys for this disease in the population of the dam project area. It is known that schistosomiasis is one of the important diseases associated with a man-made lakes. Therefore surveys to determine the presence or absence of the disease in the vicinity of the dams are essential.

4. Paragonimiasis (Lung fluke infections). Semisulcospira snails and fresh water crabs are the intermediate hosts of Paragonimus. Man gets infection by eating raw crabs. When there is an improvement in irrigation facilities in an area, there will be usually an increase in the number of snails and crabs; the people might have a good chance in contracting paragonimiasis in such area.

5. Gnathostomiasis. Gnathostoma spinigerum causes migratory swellings and some nervous symptoms in man. Fish are the important intermediate host of the infection. An increase in

the number of the fish in the area might result also in an increase in the incidence of gnathostomiasis.

6. Leptospirosis. Rats and dogs are the reservoirs of the disease and the transmission is by Leptospira spirochetes through the water. When the number of rats and dogs increase and the new settlers live in the area close to water, the chance of contracting of leptospirosis among the villagers is high and spreading of the disease amongst them from time to time is also possible.

7. Scrub typhus. Chigger mites are the vectors, and the rats and other rodents are the reservoir hosts of scrub typhus. When the populations of the vectors and the reservoirs are increased, the incidence of the infection will also rise.

8. Eosinophilic meningo-encephalitis. This disease is caused by Angiostrongylus cantonensis of which rats are the reservoirs and snails (e.g. Pila spp.) are the vector. Man acquires infection by eating raw infected snails. When the rats and the snails are increased in number and the people still continue the habit of eating raw snails, the incidence of this infection will be increased as well.

9. Malaria. The number of the anopheline vector mosquitoes of malaria may increase and/or there may be new vector species

involved in transmission due to the changes in environment. This would result in the increase of malaria cases in the area especially in the resettlement villages of Non Sang district adjacent to the forested area.

10. Nutritional status of the community. The nutritional status of the people in areas of dams water-reservoirs and good irrigation systems has not been clearly understood so far. In general, the villagers should have a better nutrition due to the increase in production of food, but in practice it may be not always be true due to many factors such as increase in infectious diseases, old customs and habits of eating, lack of hygienic latrines, etc. It is worth-while to study the nutritional status of some groups of people in this area especially the pre-school children.

In summary, the diseases which may occur and increase following the construction of the dams in Khon Kaen province of Northeast Thailand are as follows:-

(1) Hepatic and intestinal parasitic infections including opisthorchiasis, hookworm infections, intestinal fluke infections, strongyloidiasis, amoebiasis, etc.

(2) Schistosomiasis (through water; snails as transmitters)

(3) Paragonimiasis (through eating raw crabs)

(4) Gnathostomiasis (through eating raw fish)

(5) Leptospirosis (through water; rats and dogs as reservoirs)

(6) Scrub typhus (through chigger mites; rats as reservoirs)

(7) Eosinophilic meningo-encephalitis (through eating raw snails; rat as reservoirs).

(8) Malaria

(9) Changes in nutritional status of the people.

Therefore, it has been suggested that we should carry out as soon as possible the surveys on various diseases as mentioned above in order to get the basic data for the planning of the prevention and control of these diseases before they would have a chance to spread. The studies should be repeated every year or every other year in the following 4-5 years so that the medical and public health problems could be solved in time in this area.

THE AREAS UNDER STUDY

1. Resettlement Areas. The movements of considerable populations from the areas being flooded by the man-made lake to new settlement villages will involve the medical and psychological problems for both the new settlers and the indigenous population in the area with whom they come in contact. Some villages will be selected for these studies.

2. Irrigation Areas. Two major problems will arise in the rice fields and vegetable gardens. First, there will be pressures on the health patterns of the static indigenous populations in the existing rice fields and vegetable and crop producing areas, resulting from the development of irrigation, and the corresponding increase in the production and improvement of communications, together with the inevitable increased movement and intermingling of populations. Secondly, there will be changes arising from the movement into the new irrigation areas of new populations either for settlement or for seasonal labour.

3. Long established local villages. These will be used as the controls.

After studying of the geographical and other environmental factors of the areas in the vicinity of Ubol-Ratana Dam and Nong Wai Dam, we chose 9 relevant areas (map 2) for carrying out our surveys. They are as follows:-

A. Non Sang district. This district with a population of 50,000 is situated on the north bank of the man-made lake. Most of the people are indigenous with some new settlers. There is plenty of water available in this district after the construction of the dams. It is expected that the economic condition of the people in this district will be much improved due to the availability of food.

B. Resettlement Non Sang. This place with hundreds of new families settled is situated north of Non Sang district on a rising ground at the foot of a steep escarpment. Malaria is likely to be a risk in this area.

C. Ban Non Jik. All the population in this area are indigenous people, thus being suitable as controls for comparing findings with those from other areas especially the new settler area.

D. Resettlement, Ban Kok Soong. The population in this area consists of the new settlers coming from the flooded areas and from other provinces, thus being non-immune to the local endemic diseases.

E. Ban Non Payom

F. Ban Tambol Samran

These two areas are surrounded by low rice fields with a stream passing nearby. In the following 3-4 years the areas will receive the irrigation from Nong Wai Dam. The population consists of indigenous people.

G. Ban Kho Ta. The area is about 4 kilometres from Khon Kaen town, being a low land with rice fields. Its surroundings are practically the same as those in the areas E and F, but the villagers as a whole seem to be more hygienic. The people are indigenous.

H. Village, Khon Khon. This area is a suburb of Khon Kaen. The houses are scattered; there are many small water-beds in the area.

I. Ban Kok See. This is a group of villages situated in the triangular area to be irrigated by Nong Wai Dam in the next 4-5 years. There are many water-beds and small lakes in the area. Most of the people are indigenous; some are new comers.

METHODS AND PROCEDURES

1. Faecal examinations for intestinal parasitic and liver fluke infections.

A temporary field station was established in the Khon Kaen Provincial Hospital. Plastic cups for putting the faecal specimens were distributed to the villagers in the afternoon and they were collected by our team in the following morning. MIF solution was added and mixed with the faecal material. Some of the specimens were examined at the field laboratory; most of them were transported to the laboratories of the Faculty of Tropical Medicine in Bangkok where examinations for intestinal parasitic and hepatic infections were carried out by formalin-ether concentration method (AMS III). Analysis of the data obtained was made with special reference to the prevalence of the infection, the age and sex distribution and the epidemiology of the infections.

2. Surveys for schistosomiasis in man.

Skin tests using Yokogawa's antigen (obtained from S. japonicum adult worm) were preformed on the villagers, followed by examinations of the faeces by AMS III concentration method and cercaria hatching method for cases which gave positive or doubtful reactions. The eggs or miracidia of S. japonicum, when found, were fixed, stained and examined under the microscope.

3. Surveys for paragonimiasis in man.

Skin tests using P.westermani adult worm antigen (obtained from Prof. M. Yokogawa, Chiba, Japan) were performed on the villagers, followed by examinations of the sputa or faeces by a centrifugation concentration method in order to recover the eggs of P.westermani for definite diagnosis.

4. Surveys of gnathostomiasis in fish

Examinations for the third stage larvae of Gnathostoma spinigerum were also made on the fish bought from the markets of Khon Kaen. The fish was cut into small pieces which were then pressed between two thick pieces of glass and looked with naked eyes. The larvae if present were then collected and kept for further study.

5. Surveys on leptospirosis in man.

It was planned to have blood specimens drawn from the villagers and the sera be separated and sent to the laboratory in Bangkok for serological study for leptospirosis. However, since there were many difficulities in obtaining the blood samples from the villagers, we then took the specimens from the patients admitted in the surgical ward of the Khon Kaen Provinical Hospital with no evidence of any infection (such as accident cases who were assumed to be "normal" invidividuals). The sera were tested by agglutination (lysis) method against 11 serotypes

of Leptospira.* The titers higher than 1:100 were considered as positive for leptospirosis.

Later in the course of study, determination of leptospiral antibodies was made by "Dry Blood on Filter Paper" method (Sundharagiati, B. and Harinasuta, C. 1965; Trans. Roy. Soc. Trop. Med. Hyg: 59, 607). The sera of suspected cases of leptospirosis admitted into the medical ward of the Hospital were also tested by this method with satisfactory results.

6. Surveys for Leptospirosis in animals.

Rats. The animals were live-trapped from the areas and sent to the laboratory in Bangkok for further investigations. The rats were then anaesthetized and blood was drawn from the heart for serological studies. Their kidney tissues were cultured for Leptospira in Fletcher media at 28° C.

Dogs. Blood was drawn from the dogs caught in the areas. The sera were separated and sent to Bangkok for agglutination (lysis) test for Leptospira.

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* Leptospira serotypes commonly found in Thailand were L. bataviae, L. icterohaemorrhagiae, L. canicola, L. akiyami A, L. javanica, L. australis, L. hebdomadis, L. grippotyphosa, L. pomona, L. pyrogenes and L. hyos.

7. Surveys of scrub typhus among rodents.

Various rodents in the area were trapped, and chigger mites were removed, mostly from the ears, and sent to the laboratory in the Faculty of Tropical Medicine for identification.

The animals were sacrificed and the livers and spleens were minced and mixed with Snyder's diluent to make a 10 per cent suspension which was then inoculated intraperitoneally into laboratory mice (0.2 ml. per mouse). The inoculated material was also cultured in thioglycollate medium to check bacterial contamination. Further techniques and procedures in detail for isolation of rickettsia from the rodents have been described elsewhere* (Trishnananda et al, 1964).

8. Surveys of Angiostrongylus adult worms among rodents.

The rodents which had been used in the study for scrub typhus (as above) were later transferred to another laboratory where their lungs were searched for adult worms of Angiostrongylus cantonensis. In some cases identification of the species of the worm was confirmed by Prof. J.F.A.Sprent of the Department of Parasitology, University of Queensland, Brisbane, Australia.

9. Surveys on snails for Opisthorchis and Angiostrongylus infections.

Bithynia snails were collected from water reservoirs streams and various water-beds and sent to Bangkok for examinations

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* Investigation of scrub typhus in Thailand, J. Trop. Med. Hyg., 67 : 215

of cercariae of Opisthorchis viverrini. At the laboratory of the Faculty of Tropical Medicine, 4-5 snails were put into a small glass container with small amount of water and were left for 2-4 hours at room temperature, after which the water in the container was examined for cercariae of O. viverrini under a stereomicroscope. The characteristic 2 black eye-spots of the cercariae were the important criteria for diagnosis.

Pila snials were collected and examined for the third stage larvae of Angiostrongylus cantonensis*. The procedure was as follow:- The snails were removed from their shell, chopped and wrapped in gauze as a package which was then placed on a wire mesh in a funnel with a rubber tube and a clamp on its outlet. Acid pepsin solution was added into the funnel to cover the snail package (to digest the snail tissue, and the larvae, if present, will come out into the solution in the funnel). After 4-6 hours at room temperature, the clamp was released, the third stage larvae of A. cantonensis, if present, will be drained out in the solution.

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* Man can develop eosinophilic meningo-encephalitis after eating raw Pila snails containing third stage larvae of A. cantonensis.

10. Examinations of fish for Opisthorchis infection.

Fish in the markets of Khon Kaen were caught from the man-made lake, various water-beds, streams and small rivers in the province. Before buying the fish in the markets we always asked for the source of the catch. The fish were bought once or twice a week, put in ice-thermos and sent to Bangkok for further examinations. At the laboratory of the Faculty of Tropical Medicine, the pectoral fins of the fish were pulled out and examined for metacercariae of O. viverrini (more than 95% of the metacercariae were located in the flesh of the pectoral fins).

11. Blood examinations for malaria

Thick and thin blood films were made from finger tip blood of the villagers. They were stained with Field stain and examined for malaria parasites.

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Investigations on the changes of nutritional status in the children in resettlement villages have been planned. However, the operation cannot be started due to lack of funds to support the programme.

RESULTS AND DISCUSSION

The following results were obtained during June 1967- May 1969.

1. Faecal examinations

The results of the faecal examinations in the nine areas mentioned above are in Table 1-9

Table 1 Showing the results of faecal examinations for hepatic and intestinal parasites in 1, 863 persons in the area A, Non Sang district.

	No. of males	No. of females	Total
Number examined	978	885	1, 863
Number with			
parasites	772(78. 9%)	498(56. 3%)	1, 270(68. 2%)
helminths	676(69. 1%)	595(67. 2%)	1, 271(68. 2%)
protozoa	194(19. 8%)	166(18. 8%)	360(19. 3%)
Opisthorchis	590(60. 3%)	512(57. 8%)	1, 102(59. 2%)
hookworms	388(39. 7%)	261(29. 5%)	649(34. 8%)
Strongyloides	19(1. 9%)	20(2. 3%)	39(2. 1%)
Ascaris	1(0. 1%)	1(0. 1%)	2(0. 1%)
Trichuris	1(0. 1%)	1(0. 1%)	2(0. 2%)
Taenia	18(1. 8%)	17(1. 9%)	35(1. 9%)
Intestinal flukes	126(12. 9%)	98(11. 1%)	224(12. 0%)
E. histolytica	-	-	-
Giardia	58(5. 9%)	41(4. 6%)	99(5. 3%)
E. coli	127(13. 0%)	117(13. 2%)	244(13. 1%)

Table 2 Showing the results of faecal examinations for hepatic and intestinal parasites in 355 persons in the area B, Resettlement Non Sang.

	No. of males	No. of females	Total
Number examined	163	192	355
Number with			
parasites	136(83.4%)	162(84.4%)	298(83.9%)
helminths	136(83.4%)	150(78.1%)	286(80.6%)
protozoa	32(19.6%)	30(15.6%)	62(17.5%)
Opisthorchis	114(69.9%)	133(69.3%)	247(69.6%)
hookworms	72(44.2%)	72(37.5%)	144(40.6%)
Strongyloides	5(3.1%)	4(2.1%)	9(2.5%)
Ascaris	-	-	-
Trichuris	1(0.6%)	-	1(0.3%)
Taenia	3(1.8%)	2(1.0%)	5(1.4%)
Intestinal flukes	18(11.0%)	18(9.4%)	36(10.1%)
E. histolytica	-	-	-
Giardia	14(8.6%)	14(17.3%)	28(7.9%)
E. coli	15(9.2%)	15(7.8%)	30(8.5%)

Table 3 Showing the results of faecal examinations for hepatic and intestinal parasites in 464 persons in the area C, Ban Non Jik.

	No. of males	No. of females	Total
Number examined	206	258	464
Number with			
parasites	148(71.8%)	182(74.7%)	340(73.1%)
helminths	144(69.9%)	190(73.6%)	334(71.8%)
protozoa	34(16.5%)	40(15.5%)	74(16.0%)
Opisthorchis	122(59.2%)	160(62.0%)	282(60.6%)
hookworm	52(25.2%)	76(29.5%)	128(27.4%)
Strongyloides	4(1.9%)	-	4(1.0%)
Ascaris	-	-	-
Trichuris	-	2(0.8%)	2(0.4%)
Taenia	4(1.9%)	-	4(1.0%)
Intestinal flukes	30(14.6%)	46(17.8%)	76(16.2%)
E. histolytica	-	-	-
Giardia	-	-	-
E. coli	16(15.5%)	40(15.5%)	72(15.5%)

Table 4. Showing the results of faecal examinations for hepatic and intestinal parasites in 1, 971 persons in the area D, Resettlement, Ban Kok Soong.

	No. of males	No. of females	Total
Number examined	972	999	1, 971
Number with			
parasites	652(67.1%)	620(62.1%)	1, 272(64.5%)
helminths	618(63.5%)	606(60.6%)	1, 224(62.1%)
protozoa	83(8.5%)	96(9.6%)	179(9.2%)
Opisthorchis	525(54.0%)	473(47.3%)	998(50.6%)
hookworm	199(20.5%)	232(23.2%)	413(21.9%)
Ascaris	1(01.1%)	3(0.3%)	4(0.2%)
Strongyloides	5(0.5%)	5(0.5%)	10(0.5%)
Trichuris	1(0.1%)	-	1(0.05%)
Taenia	11(1.1%)	4(0.4%)	15(0.8%)
Intestinal flukes	122(12.6%)	90(9.0%)	212(10.8%)
E. histolytica	3(0.3%)	1(0.1%)	4(0.2%)
Giardia	7(0.7%)	7(0.7%)	14(0.7%)
E. coli	74(7.6%)	88(8.8%)	162(8.2%)

Table 5. Showing the results of faecal examinations for hepatic and intestinal parasites in 490 persons in the area E, Ban Non Payom.

	No. of males	No. of females	Total
Number examined	246	244	490
Number with			
parasites	156(63.4%)	142(62.3%)	308(62.9%)
helminths	150(61.0%)	136(55.7%)	286(58.4%)
protozoa	22(8.9%)	30(12.3%)	52(10.6%)
Opisthorchis	114(46.3%)	102(41.8%)	216(44.1%)
hookworm	58(23.6%)	62(25.4%)	120(24.5%)
Strongyloides	2(0.8%)	-	2(0.4%)
Ascaris	2(0.8%)	2(0.8%)	4(0.8%)
Trichuris	-	-	-
Taenia	2(0.8%)	4(1.6%)	6(1.2%)
Intestinal flukes	6(4.9%)	8(3.3%)	20(4.1%)
E. histolytica	-	-	-
Giardia	8(3.3%)	6(2.5%)	14(2.9%)
E. coli	16(6.5%)	24(9.8%)	40(8.2%)

Table 6. Showing the results of faecal examinations for hepatic and intestinal parasites in 1,122 persons in the area F, Ban Tambol Samran.

	No. of males	No. of females	Total
Number examined	511	611	1,122
Number with			
parasites	300	371(60.7%)	671(59.8%)
helminths	265	319(52.2%)	584(52.0%)
protozoa	83	125(20.5%)	208(18.5%)
Opisthorchis	183	207(33.9%)	390(27.5%)
hookworm	105	137(22.3%)	242(21.6%)
Strongyloides	4	3(4.9%)	7(0.6%)
Ascaris	-	-	-
Trichuris	1	4(6.5%)	5(0.4%)
Taenia	3	4(6.5%)	7(0.6%)
Intestinal flukes	19	19(3.1%)	38(3.4%)
E. histolytica	-	-	-
Giardia	34	52(8.5%)	86(7.7%)
E. coli	49	73(11.9%)	122(10.9%)

Table 7. Showing the results of faecal examinations for hepatic and intestinal parasites in 553 persons in the area G, Ban Kho Ta.

	No. of males	No. of females	Total
Number examined	229	324	553
Number with			
parasites	155(67.7%)	211(65.1%)	366(66.2%)
helminths	147(64.2%)	203(62.6%)	350(63.3%)
protozoa	33(14.4%)	46(14.2%)	79(14.3%)
Opisthorchis	130(56.8%)	188(58.0%)	318(57.5%)
hookworm	30(13.1%)	45(13.9%)	75(13.6%)
Ascaris	5(2.2%)	11(3.4%)	16(2.9%)
Strongyloides	1(0.4%)	-	1(0.2%)
Trichuris	-	-	-
Taenia	2(0.9%)	-	2(0.4%)
Intestinal flukes	5(2.2%)	1(0.3%)	6(1.1%)
E.histolytica	-	-	-
Giardia	6(2.6%)	7(2.2%)	13(2.4%)
E.coli	23(10.0%)	32(9.9%)	55(9.9%)

Table 8. Showing the results of faecal examinations for hepatic and intestinal parasites in 140 persons in the area H, Village, Khon Kaen.

	No. of males	No. of females	Total
Number examined	58	82	140
Number with			
parasites	35(60.3%)	51(62.2%)	86(61.3%)
helminths	32(55.2%)	49(59.8%)	81(57.5%)
protozoa	10(17.2%)	10(12.2%)	20(14.7%)
Opisthorchis	30(51.7%)	41(50.0%)	71(50.9%)
hookworm	8(13.8%)	-	8(6.9%)
Ascaris	-	1(1.2%)	1(0.6%)
Strongyloides	1(1.7%)	-	1(0.6%)
Trichuris	-	-	-
Taenia	-	2(2.4%)	2(1.2%)
Intestinal flukes	-	-	-
E. histolytica	-	-	-
Giardia	5(8.6%)	3(3.7%)	8(6.1%)
E. coli	7(12.1%)	5(6.1%)	12(9.1%)

Table 9. Showing the results of faecal examinations for hepatic and intestinal parasites in 4, 815 persons in the area I, Ban Kok See.

	No. of males	No. of females	Total
Number examined	2, 398	2, 417	4, 815
Number with			
parasites	1, 526(63. 6%)	1, 563(64. 7%)	3, 089(64. 2%)
helminths	1, 413(58. 9%)	1, 452(60. 1%)	2, 865(59. 5%)
protozoa	329(13. 7%)	334(13. 8%)	663(13, 8%)
Opisthorchis	1, 119(46. 7%)	1, 085(44. 9%)	2, 204(45. 8%)
hookworm	390(16. 3%)	501(20. 7%)	819(18. 5%)
Ascaris	19(0. 8%)	13(0. 5%)	32(0. 7%)
Strongyloides	9(0. 4%)	7(0. 3%)	16(0. 3%)
Trichuris	8(0. 3%)	6(0. 2%)	14(0. 3%)
Taenia	17(0. 7%)	15(0. 6%)	32(0. 7%)
Intestinal flukes	123(5. 1%)	90(3. 7%)	213(4. 4%)
E. histolytica	1(0. 04%)	-	1(0. 02%)
Giardia	131(5. 5%)	124(5. 1%)	255(5. 3%)
E. coli	194(8. 1%)	209(8. 6%)	403(8. 4%)

Details of the results in 9 villages in the area I are as follows:-

Table 10. Showing the results of faecal examinations for hepatic and intestinal parasites in 3 villages in the area I, i.e. (1) B. Kok-See-Proper, (2) B. Nong-Bua-Noi, and (3) B. Hua-Dong.

	(1) B. Kok-See-Proper	(2) B. Nong-Bua-Noi	(3) B. Hua-Dong
Number examined	1,110	444	296
Number with			
parasites	759(68.4%)	341(76.8%)	147(49.7%)
helminths	705(63.5%)	330(74.3%)	135(45.6%)
protozoa	192(17.3%)	68(15.3%)	27(9.1%)
Opisthorchis	569(51.3%)	301(67.8%)	99(33.4%)
hookworm	207(17.7%)	74(16.7%)	33(11.1%)
Ascaris	10(0.9%)	5(1.1%)	4(1.4%)
Strongyloides	3(0.3%)	4(0.9%)	-
Trichuris	1(0.1%)	8(1.8%)	-
Taenia	11(1.0%)	7(1.6%)	-
Intestinal flukes	35(3.2%)	-	4(1.4%)
E. histolytica	-	1(0.2%)	-
Giardia	72(6.5%)	27(6.1%)	13(4.4%)
E. coli	119(10.7%)	42(9.5%)	14(4.7%)

Table 11. Showing the results of faecal examinations for hepatic and intestinal parasites in 3 villages in the area I, i. e. (4) B. Song-Korn, (5) B. Nong-Ngu-Luam and (6) B. Karm M.

	(4) B. Song-Korn	(5) B. Nong-Ngu-Luam	(6) B. Karm M.
Number examined	299	569	428
Number with			
parasites	158(52.8%)	368(64.7%)	220(51.4%)
helminths	148(49.5%)	349(61.3%)	171(40.0%)
protozoa	18(6.0%)	70(12.3%)	91(22.3%)
Opisthorchis	102(34.1%)	235(41.3%)	119(27.8%)
hookworm	42(14.0%)	142(25.0%)	72(16.8%)
Ascaris	1(0.3%)	1(0.2%)	2(0.5%)
Strongyloides	1(0.3%)	2(0.3%)	-
Trichuris	-	2(0.3%)	1(0.2%)
Taenia	-	3(0.5%)	2(0.5%)
Intestinal flukes	-	10(1.8%)	7(1.6%)
E. histolytica	-	-	-
Giardia	4(1.3%)	21(3.7%)	37(8.6%)
E. coli	11(3.6%)	47(8.3%)	55(12.9%)

Table 12. Showing the results of faecal examinations for hepatic and intestinal parasites in 3 villages in the area I, i.e. (7) B.Sam-Rong, (8) B.Karm-Nam-Pong and (9) B.None

	(7) B.Sam-Rong	(8) B.Karm-Nam-Pong	(9) B.None
Number examined	607	389	673
Number with			
parasites	391(64.6%)	236(60.7%)	469(69.7%)
helmitnhs	374(61.1%)	226(59.1%)	427(63.4%)
protozoa	68(11.2%)	31(7.9%)	98(14.6%)
Opisthorchis	286(47.1%)	163(41.9%)	330(50.5%)
hookworm	127(20.9%)	73(18.8%)	121(18.0%)
Ascaris	4(0.6%)	2(0.5%)	3(0.5%)
Strongyloides	5(0.8%)	1(0.3%)	-
Trichuris	1(0.2%)	-	1(0.2%)
Taenia	6(1.0%)	-	3(0.5%)
Intestinal flukes	36(5.9%)	7(1.8%)	114(16.9%)
E.histolytica	-	-	-
Giardia	25(4.1%)	9(2.3%)	47(7.0%)
E.coli	42(6.9%)	22(5.7%)	51(7.6%)

For comparison, faecal surveys were also carried out in the population of neighbouring provinces, namely Udon-Thani, Kalasin and Mahasarakham provinces. The results are shown in Table 13.

Table 13. Showing the results of faecal examinations for hepatic and intestinal parasites in 2,485 persons of 3 neighbouring provinces of Khon-Kaen.

	Udon-Thani	Kalasin	Mahasarakham
Number examined	864	871	750
Number with			
parasites	741(85.8%)	719(82.5%)	641(85.4%)
helminths	741(85.8%)	703(80.7%)	631(84.1%)
protozoa	133(15.4%)	52(59.7%)	57(7.6%)
Opisthorchis	689(79.7%)	654(75.1%)	589(78.5%)
hookworm	271(31.4%)	328(37.7%)	179(23.9%)
Strongyloides	89(10.3%)	4(0.5%)	20(2.7%)
Ascaris	39(4.5%)	2(0.2%)	2(0.3%)
Trichuris	21(2.4%)	4(0.5%)	2(0.3%)
Taenia	24(2.8%)	6(0.7%)	10(1.3%)
Intestinal fluke	16(1.9%)	128(14.7%)	36(4.8%)
E.histolytica	10(1.2%)	6(0.7%)	1(0.1%)
Giardia	42(4.9%)	43(4.9%)	14(1.9%)
E.coli	30(3.5%)	11(1.3%)	42(5.6%)

The results of faecal examination for hepatic and intestinal parasitic infections can be summarized in 3 groups according to the different environments of the areas, as shown in Table 14.

Table 14. Showing the comparison of the prevalence of the hepatic and intestinal parasitic infections among the villagers in the resettlement, irrigation and existing village areas.

Parasites	Infection rate in per cent								
	Resettlements,		Irrigation,				Existing villages,		
	B.	D.	E.	F.	G.	I.	A.	C,	H.
Helminths	80.6	62.1	58.4	52.0	63.3	59.5	68.2	71.8	57.5
Protozoa	17.5	9.2	10.6	18.5	14.3	13.8	19.3	16.0	14.7
Opisthorchis	69.6	50.6	44.1	27.5	57.5	45.8	59.2	60.6	50.9
Hookworms	40.6	21.9	24.5	21.6	13.6	18.5	34.8	27.4	6.9
Intestinal flukes	10.1	10.8	4.1	3.4	1.1	4.4	12.0	16.2	0
Giardia	7.9	0.7	2.9	7.7	2.4	5.3	5.3	0	6.1

The results indicate that in general the infection rates for hepatic and intestinal parasitic infections among the villagers in the irrigation areas are lower than those in either the resettlement or the existing village areas. However, in these three areas the prevalence of helminthic infections among the population (both indigenous and settlers) were rather high (52.0-80.6 per cent), while those of protozoa were

(9.2-19.3 per cent). The infection rates for opisthorchiasis in all the areas were high (27.5-69.6 per cent), and those of hookworm infections moderate (6.9-40.6 per cent). Intestinal flukes and Giardia were found to be prevalent in some of the areas (10.1-16.2 per cent and 2.4-7.7 per cent respectively). E. histolytica infection was surprisingly very low (0-0.2 per cent).

These findings provide a baseline for further observations especially towards evaluating the progress of public health activities and implementing long term studies. They also will provide a basis for carrying out specific public health measures and towards problems which have bearing on the socio-economic development of the country as a whole.

2. Surveys for schistosomiasis in man

Skin tests using S. japonicum adult worm antigen were performed on the people in the areas under investigations (A-I, about 50-200 persons in each area). It was found that even though the positive rate in each area was about 4-9 per cent, neither the eggs nor miracidia were recovered from the faeces of the positive or doubtful cases (using both AMS III concentration method and hatching method). The details are shown in Table 15.

Table 15. Showing the results of the skin tests for S. japonicum infection in 766 persons in the areas A-I.

Area	Skin tests				
	No. exam.	Positive		Doubtful	
		No.	per cent	No.	per cent
A. Non Sang district	128	12	9.4	10	7.8
B. Resettlement, Non Sang	66	5	7.5	6	9.1
C. Ban Non Jik	82	4	4.8	5	6.1
D. Resettlement, Ban Kok Soong	170	16	9.4	14	8.2
E. Ban Non Payom	72	4	5.5	4	5.6
F. Ban Tambol Samran	86	4	5.6	5	5.8
G. Ban Kho Ta	70	4	5.7	4	5.7
H. Village, Khon Kaen	107	5	4.6	7	6.5
I. Ban Kok See	185	17	9.2	18	9.7
Total	766	71*	9.3	73*	9.5

* Examinations of the faeces of all of them (by AMS III concentration method) revealed negative for Schistosoma eggs or miracidia.

3. Surveys for paragonimiasis in man

Skin tests using P. westermani adult worm antigen were performed among the villagers of the areas A-I. The stools and sputa of those who showed positive skin reactions (20 out of 556 persons examined) were collected and examined by centrifugation concentration method. The eggs of P. westermani, however, were not found in any of them. The results are shown in Table 16.

Table 16. Showing the results of the skin tests for Paragonimus westermani infection in 556 persons in the areas A-I.

Area		Positive	
	No. exam.	No.	Per cent
A. Non Sang district	77	4	5.2
B. Resettlement, Non Sang	45	3	6.7
C. Ban Non Jik	48	1	2.1
D. Resettlement, B. Kok Soong	114	4	3.5
E. Ban Non Payom	38	1	2.6
F. Ban Tambol Samran	64	1	1.6
G. Ban Kho Ta	68	2	2.9
H. Village, Khon Kaen	50	1	2.0
I. Ban Kok See	52	1	1.9
Total	556	20	3.6

There was no evidence to show the presence of paragonimiasis in the areas under study.

4. Surveys of gnathostomiasis in fish

Fish were collected from various water-beds and canals in the areas A-I, and also were bought from the markets of Khon Kaen town. They were cut into small pieces and examined for the third stage larvae (infective stage) of Gnathostoma spinigerum using a newly devised illumination box (Daengsvang, 1965; Annual Progress Report, SEATO Medical Research Lab. P. B113). It was found that only Ophicephalus spp. fish harboured those larvae (infection rate of 8 per cent from 66 fish examined). Other species such as Cyclocheilicthys siaja, Puntius gonionotus, Hampala macrolepidota and Hampala dispar showed negative results (2,482 fishes examined).

However, it appears that gnathostomiasis is not an important disease in these areas, since there were not many cases reported from Khon Kaen Hospital during the past two years.

5. Surveys on leptospirosis in man

(1) From the surgical ward of Khon Kaen Hospital

1967-1968: The sera of 117 cases from patients of the surgical ward were tested for leptospirosis antibodies. 15 cases (12.8%) gave positive results which included the serotypes of L. bataviae(6), L. grippotyphosa(4), L. javanica(2), L. pyrogenes(1), L. hebdomadis(1) and L. pomona(1)

1968-1969: The positive rate was 18.6 per cent. The serotypes involved were L. grippotyphosa(10), L. javanica(4), L. pyrogenes(4), L. bataviae(3), L. hebdomadis(2), L. pomona(2), and L. australis(2). The results are shown in Table 17.

Table 17. Showing the results of the agglutination (lysis) test for leptospirosis antibodies from the patients in the surgical ward of Khon Kaen Hospital (regarded as "normal" individuals)

Year	No. exam.	Positive		Serotypes involved
		No.	Per cent	
1967 - 1968	117	15	12.8	6b, 4g, 2j, 1py, 1h, 1po.
1968 - 1969	145	27	18.6	10g, 4j, 4py, 3b, 2h, 2po, 2 au.

b = L. bataviae, g = L. grippotyphosa, j = L. javanica, py = L. pyrogenes, h = L. hebdomadis, po = L. pomona au = L. australis

(2) From the suspected cases of leptospirosis in the medical ward of Khon Kaen Hospital

The results are shown in Table 18.

Table 18. Showing the results of the agglutination (lysis) test for leptospirosis antibodies from the patients in the medical ward of Khon Kaen Hospital (suspected cases, "dry blood on filter paper" method being used).

Year	No. exam.	Positive		Serotypes involved
		No.	Per cent	
1967 - 1968	138	19	13.8	11j, 4g, 4py
1968 - 1969	160	31	19.4	18j, 8g, 4py, 1w.

j = L. javanica, g. = L. grippotyphosa,

py = L. pyrogenes, w = L. wolffii

The necessity of obtaining venous blood samples, which is socially disliked by the local population, has limited the number of individuals who have been tested so far for immune bodies of leptospirosis.

The results in Table 17 and 18 indicate that leptospirosis exists in the Khon Kaen area. There were many clinical cases admitted into the Khon Kaen Hospital for treatment.

Attempts are being made to establish techniques with which very small volumes of finger blood could be used. If the techniques could be established, the survey of leptospirosis in the villages would be made possible.

6. Surveys on leptospirosis in animals.

Rats. A total of 880 rodents, most being Rattus rattus, were trapped from the areas A-I during the 2 year study (1967-1969). In the first year, out of 378 rats examined, 70(18.5%) gave positive results for Leptospira by kidney culture and 15(4.0%) was positive for leptospirosis antibodies by the agglutination test. In the second year, out of 502 rats examined, 81 (16.1%) gave positive results for Leptospira by kidney culture method and 21(4.2%) were positive for leptospirosis antibodies by the agglutination test. The details of the results are shown in Table 19 and 20

Table 19 Showing the results of kidney cultures and serum agglutination tests for leptospirosis in the rodents caughts from the areas A-I in 1967-1968

Area	No. exam.	No. of positives by	
		Kidney culture	Serum agglutination test
A. Non Sang district	36	-ve	-ve
B. Resettlement Non Sang	28	-ve	-ve
C. Ban Non Jik	46	3py	-ve
D. Ressettlement Ban Kok Soong	18	-ve	-ve
E. Ban Non Payom	44	4py	1py
F. Ban Tambol Samran	46	10j	1j
G. Ban Kho Ta	36	20j	4j
H. Village, Khon Kaen	42	12j, 6py, 2au.	6j, 1py
I. Ban Kok See	82	9j, 4py	1j, 1py
Total	378	51j, 17py 2au (18.5%)	12j, 3py (4.0%)

j = L. javanica, py = L. pyrogenes, au = L. australis

Table 20 Showing the results of kidney cultures and serum agglutination tests for leptospirosis in the rodents caught from the areas A-I in 1968-1969

Area	No. exam.	No. of positives by	
		kidney culture	serum agglutination test
A. Non Sang district	47	2j	-ve
B. Resettlement Non Sang	35	1j	-ve
C. Ban Non Jik	55	1 j, 1py	-ve
D. Ressettlement Ban Kok Soong	76	8j, 1py	1j
E. Ban Non Payom	66	4j	-ve
F. Ban Tambol Samran	32	3j	-ve
G. Ban Kho Ta	45	11j, 1py	4j
H. Village, Khon Kaen	68	20j, 4py	9j
I. Ban Kok See	78	18j, 5py, 1au	6j, 1py
Total	502	68j, 12py, 1au (16.1%)	20j, 1py (4.2%)

j = L. javanica, py = L. pyrogenes, au = L. australis

Dogs. It was found that there were difficulties in obtaining blood samples from dogs in many villages. Therefore only the dogs in 3 areas (A, D and H.) were included in this study. In the first year examinations for Leptospira antibodies were made on 182 dogs, 2.7% of which gave positive results, while in the second year out of 194 dogs examined, 3.1% were positive for the agglutination test. The details of the results are shown in Table 21.

Table 21 Showing the results of serum agglutination tests for leptospirosis in the dogs in the areas A, D and H. during 1967-1969.

Area	Year	No. exam.	Positive agglutination test
A. Non Sang district	1967-1968	80	1au, 1b
	1968-1969	70	1j, 1c
D. Resettlement Ban Kok Soong	1967-1968	60	-ve
	1968-1969	66	1c
H. Village, Khon Kaen	1967-1968	42	2c, 1j
	1968-1969	58	2c, 2j
Total	1967-1968	182	2c, 1au, 1b, 1j (2.7%)
	1968-1969	194	3j, 3c (3.1%)

au = L. australis, b = L. bataviae, j = L. javanica

c = L. canicola

The results indicate that leptospirosis is prevalent in the rodents in all of the areas studied, but is found rarely in the dogs. In other word, the rodents are the important reservoir of leptospirosis in the Khon Kaen area.

7. Surveys of scrub typhus among rodents

(1) Studies of chigger mites among the rodents

During 1967-1969, a total of 312 rodents* in the areas A and I were trapped and chigger mites if present were removed from their ears and bodies. It was found that 3 species of the rodents including Rattus rattus, R. exulans and Bandicota indica harboured 4 species of chigger mites, and Leptotrombidium deliensis was observed among R. rattus and B. indica. The results are shown in Table 22,

Table 22 Showing the species of chigger mites in relation to the rodents caught from the areas A and I during 1967-1969

Trombiculid mites	Number of rodents infested with chigger mites				
	R. rattus	R. exulans	B. indica	B. bengalensis R. berdmorei	Total
	256	20	30	6	312
1. Blankaartia acuscutellaris	12	1	2	0	15
2. Gahrliepia(Walchia) disparunguis pingue	4	0	1	0	5
3. Leptotrombidium deliensis	18	0	10	0	28
4. Leptotrombidium striatum	2	1	1	0	4
Total	36	2	14	0	52

* The species of rodents include Rattus rattus (82.1%) R. exulans (6.4%), R. berdmorei (1.3%), Bandicota indica (9.6%), and B. bengalensis (0.6%)

(2) Isolation of Rickettsia tsutsugamushi from the rodents*

During 1967-1969 a total of 235 rodents in the areas A and H were caught and isolation of Rickettsia tsutsugamushi was made on them. It was found that the infection rates in the animals ranged from 6.4% to 21.4%. The details of the results are shown in Table 23 and 24.

Table 23 Showing the results of isolation of Rickettsia tsutsugamushi from the rodents caught from the area A (Non Sang district) during 1967-1969.

Species of rats	1967-1968			1968-1969		
	No. exam.	Positive		No. exam.	Positive	
		No.	%		No.	%
1. Rattus rattus	58	6	10.3	35	3	8.6
2. Rattus exulans	3	0	0	10	0	0
3. Bandicota indica	2	0	0	2	0	0
Total	63	6	9.5	47	3	6.4

* The procedures followed those of Trishnananda et al (1964), Investigation of scrub typhus in Thailand, J. Trop. Med. Hyg., 67 : 215.

Table 24 Showing the results of isolation of Rickettsia tsutsugamushi from the rodents caught from the area H (Village, Khon Kaen) during 1967 - 1969.

Species of rate	1967-1968			1968-1969		
	No. exam.	Positive		No. exam.	Positive	
		No.	%		No.	%
1. Rattus rattus	46	9	19.6	79	18	22.8
2. Rattus exulans	2	0	0	0	-	-
3. Rattus berdmorei	2	0	0	1	0	0
4. Bandicota indica	6	1	16.7	4	0	0
Total	56	10	17.9	84	18	21.4

The findings of Rickettsia tsutsugamushi in the rodents at a significant percentage and of Leptotrombidium deliensis, an important vector of scrub typhus in Thailand, in two species of the rodents indicate that scrub typhus exists in the Khon Kaen area, which is potential danger and constitutes a risk to the settlers as well as to the indigenous people.

8. Surveys for Angiostrongylus adult worms among rodents

During 1967-1969 a total of 1,019 rodents (77.6 per cent being Rattus rattus) were caught from the areas A-I and examined for Angiostrongylus cantonensis adult worms in their lungs. The worms were, however, found among the rodents in all of the areas studied, the infection rates ranging from 3.3 to 8.5 per cent. Bandicota indica gave a high incidence of infection (32.3 per cent), while Rattus rattus had a rather low incidence (2.3 per cent). The results are shown in Table 25 and 26.

Table 25. Showing the results of examinations of the rodents caught from the areas A-I for Angiostrongglus adult worms during 1967-1969.

Area	No. exam.	Positive	
		No.	per cent
A. Non Sang district	94	8	8.5
B. Resettlement, Non Sang	75	4	5.3
C. Ban Non Jik	110	5	4.5
D. Resettlement B. Kok Soong	104	7	6.7
E. Ban Non Payom	118	4	3.4
F. Ban Tambol Samran	92	5	5.4
G. Ban Kho Ta	114	6	5.3
H. Village, Khon Kaen	120	4	3.3
I. Ban Kok See	192	9	4.7
Total	1,019	52	5.1

Table 26. Showing the species of the positive rodents for *Angiostrongylus* adult worms in the areas A-I during 1967-1969

Species of rodents	No. exam.	Positive	
		No.	per cent
Bandicota indica	99	32	32.3
Bandicota bengalensis	5	-	-
Rattus rattus	791	18	2.3
Rattus berdmorei	8	2	25.0
Rattus rajah	63	-	-
Rattus exulans	53	-	-
Total	1,019	52	5.1

9. Surveys on snails

(1) For Opisthorchis infection

During 1967-1969, a total of 98,834 Bithynia snails (the first intermediate host of Opisthorchis viverrini) were collected from the areas A-I and examined for cercariae of Opisthorchis. It was found that the cercariae of Opisthorchis were observed in 30 snails in 1967-1968 (62,613 snails examined; positive rate = 0.05%) and in 12 snails in 1968-1969 (36,221 snails examined; positive rate = 0.03%). Most of the positive snails were located in the areas H (Village, Khon Kaen) and I (Ban Kok See).

The results show that the infection rate for cercariae of O. viverrini in Bithynia snails observed in two years was very low (0.04% in average). This contrasts sharply with the high incidence of opithorchiasis in man (27.5-69.6%) and in fish (results in Table 27 and 28, rate of positive metacercariae in fish = 5.9-7.2% and average number of metacercariae per fish = 9.8 - 10.0%). Factors to be considered in the maintenance of the infection in the areas are the extreme susceptibility of certain species of fish and relative resistance of others, and the fact that an infected snail continues to pour out cercariae into the water over a long period.

(2) For Angiostrongylus infection

Pila spp. which are the usual edible snails among the villagers were found in all the areas.

The species examined included Pila scutata forma, P. scutata gracilis, P. scutata exjoansa, P. polita and P. angelica. A total of 2,463 snails were examined during 1967-1969 for the presence of the infective stage of the larvae of Angiostrongylus cantonensis. It was found that the third (infective) stage of the larvae of A. cantonensis was observed in 48 snails during 1967-1968 (1,485 snails examined; positive rate = 3.2%) and in 51 snails during 1968-1969 (978 snails examined; positive rate = 5.2%)

The results of positive findings for the infective larvae of A. cantonensis in Pila snails at a considerable percentage indicate that Angiostrongylus infection is a threat in the areas where the people often eat raw snails.

10. Examination of fish for Opisthorchis infection

A total of 11,320 fish bought from the markets of Khon Kaen province were examined for metacercariae of Opisthorchis viverrini during 1967-1969 (5,783 fish in 1967-1968 and 5,537 fish in 1968-1969). Most of the fish were Cyclocheilicthys siaja, Hampala dispar and Puntius gonionotus. Metacercariae of Opisthorchis were found in

a considerable number in these fish, the infection rate of which ranged from 0.5 to 11.6 per cent and the average number of metacercariae per fish from 3.3 to 14.5. In general, the findings in the second year were a little bit higher than those in the first year. The details of the results are shown in Table 27 and 28.

Table 27. Showing the results of examinations for metacercariae of Opisthorchis viverini in the fish caught from various water-beds and lakes in Khon Kaen province (and sold in the markets) during 1967-1968.

Place	No. exam.	Positive		Total number of metacercariae	Average Number of metacercariae/fish
		No.	%		
1. Ubol-Ratana Dam Lake	1,780	85	4.8	552	6.5
2. Suburb Khon Kaen	534	62	11.6	694	11.2
3. Ban Peu	638	14	2.2	123	8.8
4. Ban Yai	440	32	7.3	249	7.8
5. Nong San	626	3	0.5	10	3.3
6. Nong Ereung	849	81	9.5	1,028	12.7
7. Nong Iard	680	48	7.1	508	10.6
8. Nong Kok See	236	16	6.8	182	11.4
Total	5,783	341	5.9	3,346	9.8

Table 28. Showing the results of examinations for metacercariae of *Opisthorchis viverrini* in the fish caught from various water-beds and lakes in Khon Kaen province (and sold in the markets) during 1968-1969.

Place	No. exam.	Positive		Total number of metacercariae	Average number of metacercariae per fish
		No.	%		
1. Ubol-Ratana Dam Lake	2,188	142	6.5	1,209	8.5
2. Suburb Khon Kaen	626	68	10.9	722	10.6
3. Ban Peu	334	8	2.4	54	6.8
4. Ban Yai	287	23	8.0	246	10.7
5. Nong San	405	4	1.0	9	2.2
6. Nong Ereung	677	63	9.3	745	11.8
7. Nong Iard	486	52	10.7	754	14.5
8. Nong Non Payom	136	6	4.4	62	10.3
9. Nong Bua Noi	398	30	7.5	368	12.3
Total	5,537	396	7.2	4,169	10.5

11. Malaria

A total of 8,931 villagers were examined for malaria parasites during 1967-1969 (4,345 persons in 1967-1968 and 4,586 persons in 1968-1969). In general, the incidence of the infection was very low, ranging from zero in the area H (Village, Khon Kaen) to 2.1 per cent in the area A (Non Sang district). This is possibly due to the active work of the Malaria Eradication Project of the Ministry of Public Health of Thailand (spraying all the houses with DDT water-dispersible powder, 5 per cent suspension, at a dosage of 2 gm per square metre once or twice a year). The details of the results of blood examination for malaria parasites are shown in Table 29 and 30.

Table 29. Showing the results of blood examination for malaria parasites in 4,345 persons in the areas A-I during 1967-1968.

Area	No. exam.	Positive for P. falciparum		Positive for P. vivax		Total positives	
		No.	%	No.	%	No.	%
A. Non Sang district	656	10	1.5	4	0.6	14	2.1
B. Resettlement, Non Sang	932	18	1.9	-	-	18	1.9
C. Ban Non Jik	412	3	0.7	-	-	3	0.7
D. Resettlement, Ban Kok Soong	124	1	0.8	-	-	1	0.8
E. Ban Non Payom	482	3	0.6	1	0.2	4	0.8
F. Ban Tambol Samran	315	2	0.6	-	-	2	0.6
G. Ban Kho Ta	320	5	1.6	-	-	5	1.6
H. Village, Khon Kaen	458	2	0.4	-	-	2	0.4
I. Ban Kok See	646	3	0.5	1	0.15	4	0.6
Total	4,345	47	1.1	6	0.1	53	1.2

Table 30 Showing the results of blood examination for malaria parasites in 4,586 persons in the areas A-I during 1968-1969.

Area	No. exam.	Positive for P. falciparum		Positive for P. vivax		Total positives	
		No.	%	No.	%	No.	%
A. Non Sang district	520	5	1.0	-	-	5	1.0
B. Resettlement Non Sang	1,014	10	1.0	1	0.1	11	1.1
C. Ban Non Jik	388	2	0.5	-	-	2	0.5
D. Resettlement Ban Kok Soong	435	2	0.5	-	-	2	0.5
E. Ban Non Payom	428	1	0.2	-	-	1	0.2
F. Ban Tambol Samran	289	2	0.7	-	-	2	0.7
G. Ban Kho Ta	209	2	1.0	-	-	2	1.0
H. Village Khon Kaen	466	-	-	-	-	-	-
I. Ban Kok See	837	3	0.4	1	0.1	4	0.5
Total	4,586	27	0.6	2	0.04	29	0.6

GENERAL DISCUSSION

The main medical and public health problems which may occur during or after the construction of dams and water reservoirs are the spread of tropical parasitic and endemic diseases such as malaria, schistosomiasis, hookworm and liver fluke infections, leptospirosis, scrub typhus, etc. The changes in the natural surroundings following the construction of the dams may enhance the increase in the species and number of various vectors such as mosquitoes for malaria and snails and fresh water fish for trematode infections. The migration of people as well as animals which may act as reservoir hosts of one or more of these diseases may help to perpetuate and disseminate certain diseases in the areas. The people in those areas may not know how to prevent these diseases or may continue eating raw fish, snails, crabs or other animals and thus be predisposed to the infections or may cause epidemic outbreak. Furthermore, the clinical manifestations of parasitic diseases usually occur only when the infections are severe, thereby imposing difficulties in the treatment and control of the diseases. Many of these diseases will affect the indigenous or migrating populations, or both, with the consequent impairment of their health. This will lead to loss of economy through loss of man-hours of labour and through low individual efficiency, eventually causing a significant delay in national development. However, all these problems could be prevented by careful studies and proper preventive programmes.

For this reason, the Faculty of Tropical Medicine, in co-operation with the Department of Health of the Ministry of Public Health has operated the surveys according to the programmes laid down by the Executive Committee with Prof. B. G. Maegraith as a special consultant. We have concentrated on major problems only, such as malaria, leptospirosis, opisthorchiasis, schistosomiasis, paragonimiasis, hookworm infections, strongyloidiasis, ascariasis, trichuriasis, intestinal flukes infections, scrub typhus and eosinophilic meningitis caused by Angiostrongylus cantonensis. The surveys were carried out in many villages of Non Sang district of Udon-thani province (areas A and B), Nam Pong and Muang districts of Khon Kaen province (areas C, D, E, F, G, H and I) which could be affected by the changes in environment.

The results described above are the figures which we obtained during our two year investigations (1967-1969). They indicate that there have been many local endemic diseases occurring among the population in the areas studied. The prevalence of opisthorchiasis was rather high, i.e. 27.5-69.6 per cent and that of hookworm infections was moderate i.e. 6.9-40.6 per cent. The intestinal fluke infections were found to be prevalent in some areas (10.1-16.2 per cent). The prevalence of other intestinal parasitic infections including strongyloidiasis, taeniasis and giardiasis was at a rather low degree, while ascariasis and trichuriasis were rarely found, and E. hisotlytica infection was nearly nil.

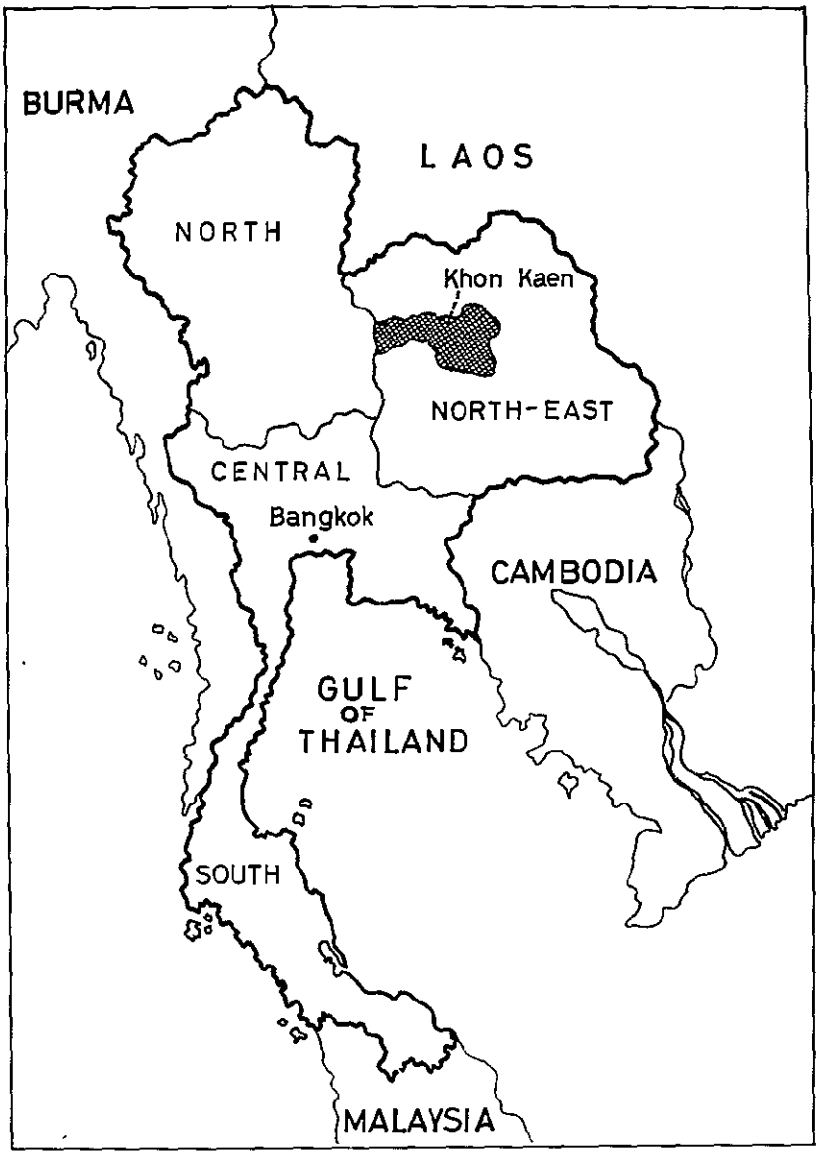
With regard to the liver fluke infection, the infection rate varied from place to place but still was not as high as those in the neighbouring provinces of Udon-thani, Kalasin and Mahasarakarm (75-79 per cent). About 6-7 per cent of the fresh-water fish in Khon Kaen province were infected with metacercariae of Opisthorchis and the average number of metacercariae per infected fish was 9-10. It is possible that the infection rate of the liver fluke infection in the areas studied may increase in the next 4-5 years if preventive measures are not implemented in time. It is suggested that the government should execute intensive health education programmes to the people as soon as possible, especially in trying to prevent them from eating raw fish as well as to persuade them to do proper faecal disposal.

Hookworm infections are rather difficult to control especially in an agricultural population. Walking with shoes is very effective in prevention of the infections but it is nearly impossible and not practicable for the Thai farmers. However, the experience of the local health officers in the areas indicate that when hygienic latrines were built and used by the villagers, a great reduction in the prevalence of hookworm infections as well as other intestinal parasitic diseases was noticed.

Since leptospirosis, scrub typhus and the adult worms of Angiostrongylus cantonensis were found not to be uncommon among the rodents in many villages, it is suggested that probably the most

important immediate action needed in these areas is to control the rodents which should be done by poisoning them, in order to prevent the diseases being transmitted to man at any time.

It should be noted from this report that the investigation has not yet been completed and since this project is a long term study, it requires at least 4-5 years in order to make logical conclusions of the changes in the patterns of the epidemiology and endemicity of the diseases occurring in the areas due to the environmental changes by the construction of the dams.



MAP 1. Showing Khon Kaen province where the investigation was carried out .

MAP 2. SHOWING THE DAMS, WATER RESERVOIR, IRRIGATION AREAS AND THE AREAS UNDER INVESTIGATION IN KHON KAEN